Arenes - Mark Scheme

Q1.

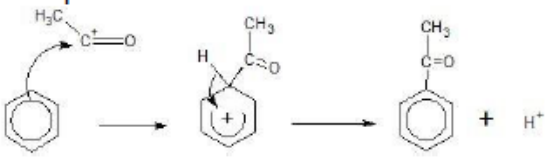
<table>
<tr><th>Question number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>(a)</td><td>This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent logical</td><td>2</td></tr>
</table></td><td>Guidance on how the mark scheme should
be applied.
The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with four indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks
(3 marks for indicative content and zero marks for linkages).

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s).</td><td>6</td></tr>
</table>

	structure with linkages and fully sustained lines of reasoning demonstrated throughout			
	Answer is partially structured with some linkages and lines of reasoning	1		
	Answer has no linkages between points and is unstructured	0		
	Indicative content:			
	Spectroscopy: (IP 1 and 2) either X-ray diffraction • all C-C bond lengths in benzene are equal		Ignore references to equal/120° bond angles	
	• but if it was a cyclic triene then they would alternate in 'short' and 'long' lengths or which is consistent with equivalent C-C bonds with a delocalised ring of electrons			
	or (infrared spectroscopy) • benzene has peaks at 1600, 1580, 1500, 1450 (cm^{-1}) for an aromatic C=C		Allow for one indicative point The infrared spectrum for benzene has a peak for an aromatic C=C at a different	
	• alkene C=C has a peak at 1669 - 1645 (cm^{-1}).		wavenumber/absorption/frequency to an alkene C=C	
	Thermochemistry: (IP 3 and 4) • enthalpy of hydrogenation is less exothermic than expected for a cyclic triene or enthalpy of combustion data		Allow benzene is more stable by ~150 kJ mol^{-1}	
	• which is consistent with the delocalisation stability of the ring from the ring of electrons		Stated enthalpies (of hydrogenation) −205 to −210 kJ mol^{-1} for benzene and −360 kJ mol^{-1} for 3 (localised C=C) double bonds	
	Type of reaction: (IP 5 and 6) • benzene undergoes substitution reactions		Allow di-substitution There are only 3 isomers of di-substituted compounds (not 4) or some di-substituted compounds are the same, e.g. 1,2 and 1,6	
	• alkenes undergo addition reactions/decolourise bromine water.			

Question number	Answer	Additional guidance	Marks
(b)(i)	An answer that makes reference to the following points: • electron pair movement from ring to electrophile (1) • formula of intermediate ion (1) • movement of electron pair to reinstate delocalised ring (1) • formulae of products. (1)	Allow arrow that starts from anywhere from within the hexagon 'Horseshoe' to cover at least three carbon atoms and facing the tetrahedral carbon with some part of the positive sign to be inside the 'horseshoe'. Exemplar mechanism:  Do not award dotted bonds unless clearly part of a 3-D structure	4

Question number	Answer	Additional guidance	Marks
(b)(ii)	• $CH_3COCl + AlCl_3 \rightarrow CH_3CO^+ + AlCl_4^-$	Accept use of $FeCl_3/Fe + 3Cl_2$	1

Question number	Answer	Additional guidance	Marks
(c)	An explanation that make reference to the following points: • lone pair of electrons on the oxygen atom increases the electron density of the ring (1) • more susceptible to attack by electrophiles. (1)		2

Question number	Answer	Additional guidance	Marks
(d)(i)	• (reactant) (conc) HNO_3 (1) • (catalyst) (conc) H_2SO_4 (1)	Ignore name Allow name Penalise reference to dilute acid once only	2

Question number	Answer		Additional guidance	Marks
(d)(ii)	• calculation of molar masses	(1)	Example of calculation: M_r of benzene = 78 **and** M_r of nitrobenzene = 123	3
	• number of moles of benzene and maximum mass of nitrobenzene	(1)	n(0.936 ÷ 78=) 0.012 (mol) m(0.012 × 123=) 1.476 (g)	
	• percentage yield of nitrobenzene to 2/3 SF	(1)	% = ((0.642 ÷ 1.476) × 100= 43.4959) = 43.5/43% Do not award 44%	